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## DOE/NASA CONTRACTOR REPORT

DOE/NASA CR-150850

### PROTOTYPE SOLAR HEATING AND COOLING SYSTEMS INCLUDING POTABLE HOT WATER (Quarterly Reports)

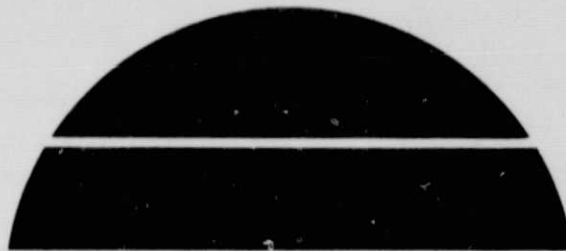
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Solaron Corporation  
Solaron Energy Systems  
Denver, Colorado 80222

Under Contract NAS8-32249 with

National Aeronautics and Space Administration  
George C. Marshall Space Flight Center, Alabama 35812

For the U. S. Department of Energy



# U.S. Department of Energy



**Solar Energy**

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15. SUPPLEMENTARY NOTES  This work was done under the technical management of Mr. Mitchell Cash, George C. Marshall Space Flight Center, Alabama 35812.			
16. ABSTRACT  These combined quarterly reports summarize the activities conducted by Solaron Corporation from November 1977 through September 1978, and cover the progress made in the development, delivery and support of two prototype solar heating and cooling systems including potable hot water. The system consists of the following subsystems: solar collector, auxiliary heating, potable hot water, storage, control, transport, and government-furnished site data acquisition.  Some reformatting of these documents has been done in the interest of clarity.			
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A.

QUARTERLY REPORT

9 NOVEMBER 1977 - 31 MARCH 1978

NAS8-32249

CONTRACT TITLE:

DEVELOPMENT, DELIVERY AND SUPPORT  
OF TWO (2) PROTOTYPE SOLAR HEATING  
AND COOLING SYSTEMS, INCLUDING  
POTABLE HOT WATER

PREPARED BY: Ray Williamson

APPROVED BY: L.E. Shaw

## Part I Summary

- 1.0 This report will summarize and bring up-to-date the reporting on this contract for the period from 9 November 1977 through 31 March 1978. The following information, as applicable, is included:  
Contract Changes, Schedules, and Technical Performance.

## Part II - Contract

- 2.0 Contract Changes - Contract Change Proposal No. CP-01 was mailed to NASA on 2 December 1977. CP-01 was implemented into the contract by Modification 2 which was received by Solaron for signature on 16 December 1977.

## Part III - Schedules

- 3.0 The revised schedule of program milestones, effective 31 March 1978, is as follows:

<u>Event</u>	<u>1st System</u>	<u>2nd System</u>
Design Approach Review	02/17/77	02/17/77
Quarterly Review	02/17/77	02/17/77
Quarterly Review	06/27/77	06/27/77
Quarterly Review	08/30/77	08/30/77
Preliminary Design Review	11/09/77	11/09/77
Prototype Design Review	05/09/78	TBD
Submit Preliminary Instrumentation Plan	04/05/78	TBD
First Article Review	05/09/78	TBD
Quarterly Review	03/28/78	TBD
Deliver/Prototype System	06/01/78	TBD
Instrumentation Required	06/15/78	TBD
Installation Review	07/15/78	TBD
Quarterly Review	07/15/78	TBD
Operation Test Review	05/01/79	TBD

## Part IV - Technical Performance

4.0 The technical performance under this Contract is reported under separate headings as follows:

- (4.1) - General and Summary
- (4.2) - Desiccant Systems
- (4.3) - Heat Pump Systems
- (4.4) - Installation Planning - Akron House.

The content is essentially a composite and summary of the technical performance as reported in the November 1977 through March 1978 monthly reports, but in addition to this it brings the technical status of the contract up to date through the Prototype Design Review (PDR<sup>1</sup>) which was held at Solaron, Denver on 28 March 1978.

### 4.1 General and Summary

The reporting period for this Quarterly Report (QR) is from 9 November 1977 through 31 March 1978. The report begins with the Preliminary Design Review (PDR) of 9 November 1977 and essentially ends with the Prototype Design Review (PDR<sup>1</sup>) of 28 March 1978.

4.1.1 Based on comparative computer simulation studies of desiccant systems - vs. - heat pump systems it was tentatively decided to use the heat pump system in the NASA/Solaron demonstration sites. It was also decided to use the heat pump in parallel configuration with the solar heating system, and to incorporate "off-peak" storage of both heating and cooling. These tentative decisions were made at the PDR of 9 November 1977 and were subject to subsequent approval after review at NASA/MSFC. Solaron accordingly submitted Change Proposal No. CP-01 to cover this change-of-direction in the program. NASA subsequently approved CP-01 and implemented the change to the contract by issuing Modification No. 2, which was received by Solaron on 16 December 1977.

4.1.2 It was also decided at the PDR to continue with testing of the desiccant system hardware, since all of the hardware for one prototype system had already been received, and to enable an actual hardware test comparison with the computer simulation studies.

4.1.3 During this period NASA was still searching for a second NASA/Solaron demonstration site. A prospective site was identified at the Gateway Vocational Technical School, Batesville, Arkansas. A site visit was made by NASA and Solaron personnel on 16-17 March 1978. On March 17 a meeting was held with Mr. Tomlinson and Mr. Breedlove at the Gateway Vocational Technical School. Bob Gunner of NASA also joined the meeting. The purpose of the meeting was to discuss a potential site for the second solar off-peak heating and cooling system. The proposed site was a 1 story single family detached home of 1700 square feet with a crawl space under the house.

Several problems became apparent in the meeting. They included the planned 4/12 roof pitch, a small five foot high mechanical area in the crawl space and the impact of the solar equipment on the appraised value of the house.

Mr. Gunner was left to negotiate these and other items.

4.1.4 A Prototype Design Review/Quarterly Review Meeting was held at Solaron/Denver on 28 March 1978. The main subjects of this meeting were as follows:

1. Priority of important items for Akron site (OTS-30) schedule:
  - a. Mr. Cash stated that it would take 3 to 4 weeks after submittal of the Proposed Instrumentation Plan (PIP) to get an Approved Instrumentation Plan (AIP), and then another 3 to 4 weeks to get sensors to the job site. Solaron estimated that the PIP could be mailed to NASA on or about 4 April 1978.



- b. Solaron agreed to conduct timely coordination with the Architect relative to system installation data and drawings.
  - c. The general contractor is to install all necessary electrical outlets for the instrumentation system (air flow sensors, SDAS, Telephone Coupler, etc.).
  - d. Solaron is to mail 8 sets of completed installation drawings for OTS-30 to NASA and 2 or 3 sets to the Architect.
  - e. Solaron to check with IBM to get wattage of electrical power required by the air flow sensors (qty: 4 sensors).
- 2. Solaron was instructed by Mr. Cash to submit a Change Proposal (CP) to the Contract to cover system installation; installation of sensors; and maintenance and logistics for a period of one (1) year. Mr. Cash estimated two weeks time to get approval of the CP after submittal.
  - 2. Mr. Cash stated that Solaron should prepare documentation to support Verification and Development Plans. He wants a complete package of supporting data.
  - 4. Mr. Cash wants Installation, Operating and Maintenance Manual (either separate or combined into one manual) in time to review prior to installation of systems at job site.
  - 5. Mr. Cash wants the Design Brochure for Architects and Engineers to be about 4 to 6 pages. He said that something similar to our Sweet's brochure would be what he is looking for.
  - 6. Final Reports: One each for Desiccant Systems and Heat Pump Systems is required. These should be composite reports to include everything done under the Contract. Mr. Oonk is to send his "Desiccant Systems" paper to NASA as a "preliminary report".

#### 4.1.5 Preliminary Instrumentation Plan (PIP)

Preparation of the PIP was dependent on the receipt of "Instrumentation Installation Guidelines - SOLAR/0001-77/15" which was received by Solaron on 27 February 1978. Work was immediately begun on preparation of the PIP and it was essentially completed by the end of March. Preparation of installation drawings and specifications for the installation of instrumentation could not proceed prior to completion of the PIP. At the end of March the PIP was scheduled for 4 April 1978 and instrumentation installation drawings and specifications by late April.

#### 4.1.6 Verification Plan (VP)

Work on the Verification Plan was begun in February but was discontinued in favor of the PIP when it became the most urgent order of business.

#### 4.1.7 Documentation

All documentation pertinent to the contract has been submitted with the monthly reports November 1977 through March 1978 and are not duplicated here.

### 4.2 Desiccant Systems

The first run of hardware component testing on the desiccant dehumidifier unit was completed by Bry-Air in Sunbury, Ohio on 2 November and reports received by Solaron on 8 November 1978. These results were forwarded to the University of Wisconsin for comparison with their previously run computer simulation model of the same piece of hardware. The subsequent sequence of events relative to the desiccant system tests/studies is covered in following paragraphs.

Note: Please refer to the previous Quarterly Report (DOE/NASA CR-150576) Paragraph 4.1, 4.2 and Attachments I & II for the previous work/studies done on the desiccant system.

- 4.2.1 The University of Wisconsin made a comparison of the Bry-Air test results on the desiccant dryer and their own computer simulation results. There was a considerable discrepancy between the two, and it was suspected that there must be a considerable loss of energy from the dryer unit to the ambient.
- 4.2.2 The University of Wisconsin started work to refine the model to have the same input-output conditions as revealed by the test results. The purpose of this effort was to have a more compatible model for predicting system performance.
- 4.2.3 Solaron continued negotiations with Bry-Air and the University of Wisconsin in an effort to define the discrepancies between the test results and the computer model. A Solaron/Wisconsin/Bry-Air meeting was planned for January at Sunbury, Ohio to try to identify the roots of the problem.
- 4.2.4 The scheduled meeting was held at Bry-Air in early January. It was commonly agreed that the basic cause of the problem was excessive heat loss of the dryer unit to ambient. Bry-Air agreed to add insulation to the unit to lower the heat loss and run a new set of tests. The new test conditions will be adequate to make a critical comparison of actual hardware performance with computer modeling predictions. In this effort to achieve good agreement it will also be necessary to make some changes in the modeling procedure. Specifically, the dehumidifier model will be modified to include the effects of additional sensible heat transfer between the moist, cool process air and the hot, dry regeneration air. This sensible heat transfer comes from the supporting steel frame-work of the

wheel and is presently not accounted for in the model. When good agreement is achieved, the model will be an excellent tool in predicting and analyzing desiccant cooling systems using this particular hardware as a system component. Results of this test/-analysis program will be covered in subsequent reporting.

4.2.5 Insulation was installed around the dehumidifier and one additional data point was taken by Bry-Air during February. These data came much closer to an energy balance, however, the energy balance still did not close. This indicated that the heat transfer from the dehumidifier did account for the lack of closure in the original data, but that even with the additional insulation, there is still significant heat transfer from the dehumidifier to the surroundings. These data were sent to the University of Wisconsin where the model will be run at conditions identical to the data and the results compared. It will probably be necessary to revise the model to include the effects of the cabinet heat loss in order to be able to accurately predict the dehumidifier performance.

4.2.6 During March, three final component test points of the dehumidifier were agreed upon and Bry-Air proceeded to test at these conditions. These three test points were as follows:

Process In	Regen. In	Flow Rate	Wheel Speed
75 <sup>0</sup> , 0.01 lb./lb.	175 <sup>0</sup> , 0.02 lb./lb.	800 cfm	32 min/rev
75 <sup>0</sup> , 0.01 lb./lb.	175 <sup>0</sup> , 0.02 lb./lb.	1200 cfm	16 min/rev
75 <sup>0</sup> , 0.01 lb./lb.	175 <sup>0</sup> , 0.02 lb./lb.	1200 cfm	32 min/rev

These test points will allow a parametric study of the effects of wheel speed and flow rate per unit mass of desiccant on overall dehumidifier performance. These tests are to be completed by Bry-Air by May 1, 1978.

The University of Wisconsin is still at work modifying the dehumidifier model to account for the additional heat transfer between the process and regeneration air and between the cabinet and the ambient.

#### 4.3 Heat Pump Systems

Just prior to this reporting period Carrier completed their scheduled computer simulation runs of the "off-peak" system and "dual source" system with a 2°C bed temperature lower limit. These simulation results were then compared to the results of the "parallel" system and "dual source" system with a 15°C bed temperature lower limit. These comparisons indicated that the "parallel" system as compared to the "dual source" system uses the least amount of conventional energy for heating and cooling. Please refer to the previous Quarterly Report, DOE/NASA CR-150576, Attachment II for the details of the comparison and analysis.

4.3.1 Following NASA's decision to install an "off-peak" heat pump system with storage for heating and cooling, Solaron negotiated with Carrier for additional simulations to optimize the "off-peak" system for the Akron site, and to identify corresponding heat pump hardware.

4.3.2 A new "schedule of work" was finalized with Carrier and approved by NASA. The outline of work to be done by Carrier, with estimated completion dates, is as follows:

##### Outline of Work

##### Estimated Completion Date

#### I. Equipment Selection

03/01/78

1. Review information from Solaron
2. Tube-in-tube heat exchanger, expansion valve filter drier, check valve, interconnecting refrigerant lines, etc.
3. Tube-in-tube heat exchanger drawings.
4. Heating-cooling water coil and fan system.
5. Summary report.

## II. System Rating Data

03/08/78

1. Heat pump rating data (four modes with special tube-in-tube heat exchanger).
2. Heating-cooling water coil and fan system rating data (summarize manufactured data).

## III. Annual System Studies

04/20/78

1. Write FORTRAN Heat pump model for TRNSYS.
2. Write coil model for TRNSYS - heating and cooling.
3. Revise "off-peak" TRNSYS Program.
4. Revise and run new weather data for each of demonstration locations.
5. Run program - one annual study for each of two locations.

## IV. Consultation, Travel, Etc.

07/01/78

1. Four trips.
2. Miscellaneous consultation.

4.3.3 Simultaneous with Carrier negotiations, Solaron worked on a prototype control system to be used in the Akron site (OTS-30) installation.

4.3.4 Solaron issued Purchase Order No. 002533 to Carrier Corp. on 1 February 1978 for the equipment selection and analytical work necessary for both demonstration sites relative to the "off-peak" heat pump system. The outline of work and estimated completion dates remain the same as shown above in Paragraph 4.3.3. Carrier's initial work during February was in developing the heat pump performance characteristics of the 38HQ-134 compressor unit and the 38HQ-940 outdoor unit operating in conjunction with tube-in-tube Freon/water heat exchanger. In a parallel effort, Solaron was working on pump, valves and heating/cooling coil selection. Also, several optional piping schematics were being investigated.

4.3.5 During March Carrier derived the calculated performance of the 3EQ-134 compressor unit, the 3EQ-940 outdoor unit, and the "coaxial" (tube-in-tube) heat exchanger operating in conjunction with each other in the system. This included basic heat exchanger analysis and selection of the optimal 15 gpm water flow rate. These calculated performance data were then used to size the heating/cooling coil in correspondence with the load on the house.

Carrier also assisted in selection of some of the control devices. These included a low pressure controller to prevent freezing of the water, a low ambient temperature control to stop the compressor at the low set point, and a water flow switch to prevent compressor operation whenever there is inadequate water flow through the coaxial heat exchanger.

4.3.6 During March Solaron completed the system control schematic, wiring diagram and control unit for the "off-peak" heat pump system with storage for both heating and cooling. The prototype control unit is designed to interface with the Solaron HC0116 solar system controller and the controls supplied with the Carrier heat pump components.

A liquid storage tank was tentatively selected. This tank is an unpressurized, 1000 gallon, externally insulated and epoxy lined steel tank manufactured by Eaton Metal Products of Denver. The tank will be supplied with all the necessary pipe openings for water flow in and out of the tank and control and monitoring sensors. Further, the tank is to be supplied with an electronic float control and valve, and an overflow port.

Motorized valves were tentatively selected during March. These valves are standard 3-way valves available from Honeywell and will be ordered along Honeywell's standard valve motors and linkages. The valves were selected at 1-1/2 inches which allows 15 gpm water flow at about 0.85 ft. of head loss. The necessary pumps for the system were tentatively picked as two Grundfos 26-64 1/12 horsepower pumps. These two pumps in series offer the required head versus flow requirements at the minimum (1/6 hp) power input.

Also, a heating and cooling coil was selected. Selection of this coil was somewhat complex in that it is necessary that this coil be able to meet the house design cooling load (sensible and latent) when being used in the cooling from heat pump mode, and simultaneously not allow the water loop temperature to fall below 40°F, or rise above 130°F in the heating from heat pump mode. The coil tentatively selected is a 4 row Pace 21' x 24" coil.

#### 4.4 Installation Planning - Akron House (OTS-30)

Installation drawings and specifications for the desiccant system were completed prior to the preliminary Design Review on 9 November 1977. The decision at that meeting to switch from a desiccant to heat pump system made the desiccant installation drawings obsolete in that virtually a complete revision was required to accommodate the heat pump system.

4.4.1 Installation planning could not begin immediately on OTS-30 because it was first of all necessary to define the system and to select hardware components.

4.4.2 Preliminary sketch layouts were made in January with the information that was available. By the end of February the installation drawings for the system installation were 90% complete and by the end of March they were complete except for minor details. This does not account for the instrumentation system which is covered separately in paragraph 4.1.5.





B.  
QUARTERLY REPORT  
1 APRIL 1978 - 30 JUNE 1978  
NAS8-32249

CONTRACT TITLE:

DEVELOPMENT, DELIVERY AND SUPPORT  
OF TWO (2) PROTOTYPE SOLAR HEATING  
AND COOLING SYSTEMS, INCLUDING  
POTABLE HOT WATER

PREPARED BY: Ray Williamson

APPROVED BY: L.E. Shaw

F-1

## Part I - Summary

- 1.0 This report will summarize and bring up-to-date the reporting on this contract for the period from 1 April 1978 through 30 June 1978. The following information, as applicable, is included: Contract Changes, Schedules, and Technical Performance.

## Part II - Contract

- 2.0 Contract Changes - Contract Change Proposal No. CP-02 was mailed to NASA on 31 May 1978.

## Part III - Schedules

- 3.0 The revised schedule of program milestones, as submitted with Change Proposal CP-02, is as follows:

<u>Event</u>	<u>1st System</u>	<u>2nd System</u>
Design Approach Review	02/17/77	02/17/77
Quarterly Review	02/17/77	02/17/77
Quarterly Review	06/27/77	06/27/77
Quarterly Review	08/30/77	08/30/77
Preliminary Design Review	11/09/77	11/09/77
Prototype Design Review	03/28/78	TBD
Submit Preliminary Instrumentation Plan	04/04/78	TBD
Quarterly Review	05/16/78	TBD
Instrumentation Required	07/01/78	TBD
First Article Review	08/01/78	TBD
Deliver/Prototype System	08/01/78	TBD
Installation Acceptance Review	08/01/78	TBD
Quarterly Review	08/01/78	TBD
Quarterly Review	11/01/78	TBD

Quarterly Review	02/15/78	TBD
Quarterly Review	05/15/78	TBD
Quarterly Review	08/15/79	TBD
Operation Test Review	08/15/79	TBD
Systems Maintenance End Date	09/30/79	TBD
Complete Contract Requirements	10/15/79	TBD

- Notes:
1. All dates prior to date of this report are actual dates of completion.
  2. TBD's are to be determined after selection of the second demonstration site is finalized.

### 3.1 AKRON HOUSE (OTS-30) CONSTRUCTION SCHEDULE

	<u>Work Item</u>	<u>Start</u>	<u>Complete</u>
1.	Rock Box (except Rock by 6/30)	6/12	6/16
2.	Training (evenings)	5/22	5/23
3.	Collector Installation	5/23	5/25
4.	Ductwork, Electrical Wiring, Carrier Heat Pump Equipment, Piping and Controller Installation	5/22	7/10
5.	IBM Instrumentation & SDAS Training	6/28	6/28
6.	Instrumentation Installation Install sensors Wire to J-box SDAS Installation	6/29	7/10
7.	System Start-up	7/11	7/14
8.	Instrumentation Start-up (SDAS Activation)	7/24	7/27
9.	Installation acceptance Review	8/9	8/10

- Note:
1. Shipment of instrumentation hardware from IBM complete by 7/6 via Air (Emery) per Mitch Cash 6/20/78.
  2. Dates prior to 6/30/78 as shown above are actual dates of completion.

## Part IV - Technical Performance

4.0 The technical performance under this Contract is reported under separate headings as follows:

- (4.1) - General and Summary
- (4.2) - Desiccant Systems
- (4.3) - Heat Pump Systems
- (4.4) - Installation Planning and Equipment  
Installation - Akron House

The content is essentially a composite and summary of the technical performance as reported in the April 1978 through June 1978 monthly reports, but in addition to this it brings the technical status of the contract up to date through the IBM training session which was held at Akron, Ohio on 28 June 1978.

### 4.1 General and Summary

The reporting period for this Quarterly Report (QR) is from 1 April 1978 through 30 June 1978. The report begins after the Prototype Design Review (PDR<sup>1</sup>) of 28 March 1978 and essentially ends with the IBM training session on instrumentation installation which was held on 28 June 1978 in Akron, Ohio.

4.1.1 As a result of the Quarterly Review meeting on 28 March 1978, Solaron prepared a second Change Proposal (CP-02) to the Contract to cover system installation; installation of sensors; and maintenance and logistics for a period of one (1) year. CP-02 was mailed to NASA on 31 May 1978. Approval of CP-02 had not been received as of the end of June, but receipt was anticipated during July.

4.1.2 The Proposed Instrumentation Plan (PIP) was completed and 10 copies mailed to NASA/MSFC, Attn: FA02/Mr. Ed Hastings on 4 April 1978. Additional supplementary information relative to operating modes along with 11 mode schematics covering each of the separate operating modes was mailed 13 April 1978 (same addressee). These data were coordinated by telephone with Frank Digesu, George Mizell and Haskel Berry of IBM.

The Approved Instrumentation Plan (AIP) was received by Solaron in late May. It was exactly the same as Solaron's PIP except for the ranges on some of the sensors and the addition of four (4) position switches for the motorized 3-way control valves in the heat-pump water circuits. The bid package for installation was revised accordingly and revised prices were received as reflected in Change Proposal CP-02.

4.1.3 A Quarterly Review meeting on the subject contract was held at Solaron/Denver on 16 May 1978.

I. The attendees were as follows:

<u>Name</u>	<u>Representing</u>
Mitchell Cash	NASA
Ott Salzwimmer	AMHA
Ed Shackelford	Solaron
L.E. Shaw	Solaron
John Meeker	Solaron
Mike Faybik	Solaron
Rod Oonk	Solaron
Don Bloomquist	Solaron

II. The primary concern of the meeting was the scheduled completion of Akron House, OTS-30. The significant facts bearing on this subject, in random order, are as follows:

A. The Akron Metropolitan Housing Authority (AMHA) fiscal year ends 30 June 1978.

B. The AMHA Parade of Homes commences on 1 July 1978, and it is required by AMHA that OTS-30 be completed to a stage where it can be used as a "Solar Show Home". This means that the solar heating/cooling system must be installed and operating, but does not mean that the Instrumentation/SDAS system be completed.

C. The schedule for completion of house construction is being seriously impacted by delay in the delivery of solar equipment and letting of subcontracts for installation of this equipment.

D. The architect, Barbitta, James & Assoc., has been released from any further responsibility for this project. All future coordination shall be conducted with Ott Salzwimmer of AMHA and/or Hank Huth, the general contractor.

E. The most urgent items that prevent "closing" the house, "dry-walling" and shingling the roof are:

1. Installation of the Rock Box (note: rocks may follow later if suitable provisions are made for getting them in),
2. Moving the Heat Pump 1000 gallon storage tank into the mechanical equipment room,
3. Installation of the solar collectors on the roof,
4. Installation of the house distribution ducting and ducting in the vertical chase from the mechanical equipment room to the attic, and
5. Installation of electrical conduit and/or "hidden" wiring as required.

F. A timely schedule for Field Services and Engineering site supervision, inspection and training must be worked out to be compatible with a 1 July 1978 "Turn Key" date.

G. To meet schedule requirements, the bids from installation subcontractors must be received no later than noon Wednesday, 17 May 1978.

H. Solaron is to conduct training sessions for the installation operating and maintenance contractor prior to system installation. AMHA will arrange for a suitable meeting room and plans to be represented in attendance. Solaron is to notify AMHA of specific dates in time to facilitate arrangements.

I. AMHA is to provide a 1-1/2" plastic duct from the Mechanical Room to the attic to be used for low voltage control and instrumentation wiring.

J. AMHA agreed to supply Solaron (Rod Oonk) with sepias or second originals of the House (OTS-30) Plans.

K. IBM will conduct a separate training session for the contractor selected to install the instrumentation system. This session will cover location of sensors, requirements and special considerations for instrumentation wiring, and J-Box and SDAS installation. It would be well for AMHA and Solaron to be represented at this session.

### III. Other Items

A. The Quarterly Review Meeting held at Solaron/Denver on 23 March is officially designated by Mr. Cash as the Prototype Design Review in that final decisions on system configuration were made at that time.

B. NASA is in negotiation with T.V.A. relative to a second Solaron/NASA demonstration site. Mr. Cash said that T.V.A.'s electrical power production has gone from the original 100% Hydro to a current rate on the order of 10% Hydro, the 90% being supplied essentially by coal fired generation.

One T.V.A. site under consideration is Duffield, Virginia, which is near Bristol, which is virtually on the line between SW Virginia and NE Tennessee.

C. Mr. Cash gave Solaron the following ground rule for installation pricing:

IBM is responsible for installation of the "data package".

Solaron is responsible for maintenance of the sensors for the period from acceptance of the system by NASA through 30 September 1979, relative to the Akron (OTS-30) site. Solaron should, therefore, include the cost of maintenance of sensors in its price proposal for the installation phase.

D. The Verification Plan in its present state of development was reviewed by Mr. Cash and he said that when completed in the format shown that it would be acceptable.

E. The Change Proposal to the Contract (CP-02) in rough draft, less pricing and with incomplete schedule, was shown to Mr. Cash. Pricing is delayed for the receipt of bids from subcontractors.



## 4.2 Desiccant Systems

Bry-Air changed motors to obtain the required 1200 cfm and obtained three additional test points on the dehumidifier. The data for these tests were received in late May.

The technical paper "Performance of Solar-Desiccant Cooling System in New York City" was prepared during this quarter for eventual presentation at the International Solar Energy Society Meeting in Denver in August.

## 4.3 Heat Pump Systems

During this quarter, work continued by Solaron and Carrier to complete engineering and delivery of the heat pump systems.

### 4.3.1 During April, Solaron completed the point-to-point control wiring diagram of the complete solar heat pump off-peak heating and cooling system.

All equipment previously listed in the March report was ordered during April. This includes the tank, pumps, motorized valves and air/water heat transfer coil.

Carrier delivered to Solaron the completed summary report on the performance of the compressor, outdoor unit, and coaxial heat exchanger.

### 4.3.2 During May, several snags developed in the delivery of the necessary hardware for the Akron system. Specifically, Packless Heat Exchangers, Inc. was having difficulty in delivery of the coaxial heat exchanger to Carrier, and the fabrication of the off-peak controller was delayed because of delayed delivery of the necessary relays.

Also, the motors, linkages and valves for the motorized valves in the Akron system were received, assembled here at Solaron and forwarded to Akron.

Work was begun in May on a technical paper covering the heat pump system simulations. This paper will be presented at the August meeting of ISES.

4.3.3 During May, Carrier assisted in the struggle to get the necessary hardware to complete the coaxial heat exchanger. Also, Carrier began work on the simulation of the Akron system. This initial work included examination of the house drawings and system specifications, establishment of operating modes, control settings and other preliminary information.

4.3.4 All the necessary hardware for the Akron job arrived at Akron during June. The last item, the control unit was received at Solaron, checked out and delivered to Akron on 27 June 1978.

4.3.5 During June, Carrier received the coaxial heat exchanger from Packless, assembled it along with the expansion valve, filter/drier, and check valve into the coaxial heat exchanger unit and delivered it to Akron. Carrier continued their effort on the modelling of the system for Akron during June. A preliminary information flow diagram was completed for the simulation model.

#### 4.4 Installation Planning & Equipment Installation - Akron House (OTS-30)

The planning for equipment installation continued through the quarter, but was delayed due to house design changes, delay of construction due to bad weather and other reasons.

4.4.1 Changes in design of the house plans delayed their receipt at Solaron until 17 April. The change in the house plans caused a significant change to the layout and arrangement of the solar/heat pump equipment. This delayed the completion of installation drawings and specifications into late April.

The above changes also caused a delay in design and installation drawings for the instrumentation sensors and system interfaces in that this work could not be done prior to completion of solar/heat pump equipment installation drawings.

All of the above work was thoroughly coordinated with the project Architect, Barbitta James and Associates.

Installation constraints and interface requirements were coordinated in the purchase of equipment including pumps, valves, heat exchangers and tanks.

4.4.2 As a result of on-site negotiations in Akron, Ohio with the systems installation sub-contractor, a few minor changes in the installation plans were identified. These changes were made on Solaron drawings D1000A - Plans and Elevations, and D1001A - Mechanical Room and resubmitted for rebid, which resulted in a reduction of about \$2000.00 in the bid price. This reduction was reflected in the pricing of CP-02.

4.4.3 The schedules for construction of the demonstration house, and subsequently installation of the Solaron heating/cooling equipment, were delayed by weather and other extraneous factors. The completion schedule became a critical matter with the owner of the house, Akron Metropolitan Housing Authority (AMHA), as they were planning an "Open House - Parade of Homes" for the general public to begin on 1 July 1978. This caused the concentration of the Quarterly review meeting of 16 May 1978 to be primarily on the completion schedule for the Akron House, with Ott Salzwimmer of AMHA in attendance.

4.4.4 The solar collectors were successfully installed on the roof 23, 24, 25 May 1978 under Solaron supervision.

System installation was in full progress throughout June, but installation of the instrumentation system could not run concurrently because the sensors and appurtenant instrumentation hardware had not as yet been received.

4.4.5 The installation drawings and specifications forwarded to NASA with the April report and revisions forwarded with the May report remained unchanged throughout June.

4.4.6 The date for the Akron Metropolitan Housing Authority (AMHA) Parade of Homes has been rescheduled to 15 August 1978. This will give adequate time to complete the OTS-30 installation including instrumentation and have everything checked out prior to open house for public viewing.



C.  
QUARTERLY REPORT

1 JULY 1978 - 30 SEPTEMBER 1978

NAS8-32249

CONTRACT TITLE:

DEVELOPMENT, DELIVERY AND SUPPORT OF  
TWO (2) PROTOTYPE SOLAR HEATING AND  
COOLING SYSTEMS, INCLUDING POTABLE HOT WATER

PREPARED BY: Ray Williamson

APPROVED BY: L.E. Shaw

C-1

## Part I - Summary

- 1.0 This report will summarize and bring up-to-date the reporting on this contract for the period from 1 July 1978 through 30 September 1978. The following information, as applicable, is included: Contract Changes, Schedules, Technical Performance and Maintenance Log.

## Part II - Contract

- 2.0 Contract Changes - Supplemental Agreement modification No. 3 was received by Solaron on August 14, 1978.

## Part III - Schedules

- 3.0 The revised schedule of program milestones, as approved by Supplemental Agreement, modification No. 3, is as follows:

<u>Event</u>	<u>1st System</u>	<u>2nd System</u>
Design Approach Review	02/17/77	02/17/77
Quarterly Review	02/17/77	02/17/77
Quarterly Review	06/27/77	06/27/77
Quarterly Review	08/30/77	08/30/77
Preliminary Design Review	11/09/77	11/09/77
Prototype Design Review	03/27/78	TBD
Submit Preliminary Instrumentation Plan	04/04/78	TBD
Quarterly Review	05/16/78	TBD
Instrumentation Required	07/01/78	TBD
First Article Review	07/29/78	TBD
Deliver/Prototype System	07/29/78	TBD
Installation Acceptance Review	08/24/78	TBD
Quarterly Review	08/24/78	TBD
Quarterly Review	11/01/78	TBD

Quarterly Review	02/15/78	TBD
Quarterly Review	05/15/78	TBD
Quarterly Review	08/15/79	TBD
Operation Test Review	08/15/79	TBD
Systems Maintenance End Date	09/30/79	TBD
Complete Contract Requirements	10/15/79	TBD

- Notes:
1. All dates prior to date of this report are actual dates of completion.
  2. TBD's are to be determined after selection of the second demonstration site is finalized.

#### Part IV - Technical Performance

4.0 The technical performance under this Contract is reported under separate headings as follows:

- (4.1) - General and Summary
- (4.2) - Desiccant Systems
- (4.3) - Heat Pump Systems
- (4.4) - Installation Planning and Equipment  
Installation - Akron House
- (4.5) - Installation Check-out, Debugging - Akron  
House (OTS-30)
- (4.6) - Installation Coordination - Proposed  
Virginia House (OTS-29)

The content is essentially a composite and summary of the technical performance as reported in the July 1978 through September 1978 monthly reports.

#### 4.1 General and Summary

The reporting period for this Quarterly Report (QR) is from 1 July 1978 through 30 September 1978.

4.1.1 A Quarterly Review meeting in the Subject Contract was held at Akron, Ohio on August 24, 1978.

I. The attendees were as follows:

<u>Name</u>	<u>Representing</u>
Mitchell Cash	NASA
L.E. Shaw	Solaron
Rene' Jensen	Solaron

II. Items discussed were the Approved Instrumentation Plan, required changes in the off-peak system plumbing and a general review of early data from the Akron (OTS-30) installation.

#### 4.2 Desiccant Systems

Due to the selection of the off-peak heat pump system for the Akron (OTS-30) installation, no further work has been completed on desiccant systems.

#### 4.3 Heat Pump Systems

Start up of the Akron demonstration house Heat Pump System took place on July 25 through July 29, 1978. It was necessary to change both of the expansion valve power elements from low MOP types to standard air conditioning type elements. The system, with the valve changes, performed as calculated in the heating mode. In the cooling mode, capacity was about as calculated, but the suction pressure at the compressor was lower than expected. This lower operating pressure was caused by a slightly over capacity compressor matched with a slightly under capacity evaporator.

It is planned to observe the unit later when outdoor temperatures drop to the 30°F to 40°F level. This will give us a chance to check the heat pump during the defrost mode.



The heat pump is performing satisfactorily in both heating and cooling modes. No problems are anticipated.

#### 4.4 Installation Planning and Equipment Installation - Akron House (OTS-30)

During July, the system installation in Akron was completed and the system started up. Start up was delayed by approximately two days due to problems encountered in the system layout. The heating and cooling coil was initially piped backwards and correcting this error resulted in an unbleedable air pocket in the system piping which in turn was corrected. The automatic air vents in the liquid system were found to be unacceptable and were replaced with manual vents. In addition, the heating and cooling coil was not supplied with a drain pan and consequently one was added.

A more general undesirable characteristic of the installation was the fact that the heating and cooling coil and much of the piping was higher than the tank. It would have been easier to fill the system if all the piping and water components had been below the tank water level.

#### 4.5 Installation Check-out, Debugging - Akron House (OTS-30)

During August, Solaron visited the Akron site a second and third time. In the second visit the SDAS was started by IBM and the Solaron representative assisted by operating the system in the various modes. Problems noted in the instrumentation were, (1) the watt-meter for the off-peak pumps was undersized and will need to be replaced, (2) five of the six water temperature wells are too short, (3) the sixth water temperature measurement point has a probe which is too short. Action is being taken to correct these problems. The watt-meter was replaced during the second visit.

The third site visit was needed for acceptance of the installation by NASA. During this visit, it was discovered that air in the water lines had caused a system shutdown. As of now, it is unclear as to whether this air problem is a recurring problem or one of residual air left over from the original start-up. A second problem is that of frequent power failures causing the time clock to lose the correct timing. Efforts are now underway to completely analyze the air problem to see what corrective action should be taken, as well as development of a battery back-up for the off-peak time clock, to allow it to run during power failures.

Other problems noted in the data analyses were apparent air leaks in the ductwork, and a piping/thermal siphoning problem in the domestic water loop. The piping problems in the water loop will be corrected shortly. The apparent air leak problems will require further analysis to discover the exact corrective action needed.

On September 7, 1978, Solaron received a letter from Mr. Mitchell Cash with instructions to correct the following items prior to receiving Akron installation acceptance:

- (a) T206, T207, T256, T257, T401 and T451 are to be fixed so that they extend into the pipe flow and are secured by the clamping nut.
- (b) The tempering valve is set for too low a house temperature; and, also needs a check valve ahead of it.
- (c) The tempering valve cold water supply has to be moved so that tempering water does not register on W302.
- (d) T302 has to be moved farther from the tank so it will not give false readings.

- (e) A means needs to be provided so that the clock for off-peak operation stays at the set time, and will not be affected by power outages.
- (f) W400 appears to have two flow rates and this needs to be investigated.
- (g) All air has to be eliminated from the piping and kept out. The best way to accomplish this should be discussed with me and the Science and Engineering Office.
- (h) The mechanical room needs to be vented. If this was not included in your contract with Temperature Control, please advise me.
- (i) The domestic hot water (DHW) circulating supply must be moved to the tank bottom outlet and a check valve added to prevent thermal syphoning in this loop.
- (j) The hum in the heat exchanger and the chatter in the duct (damper?) need to be eliminated.
- (k) In some modes, the DHW circulating pump operates when there is no flow through the heat exchanger. The control system needs to be modified to eliminate this.
- (l) The reason for the high infiltration in the collectors in some modes should be investigated. If not corrected, it will degrade performance. Also, the reason for the big difference in W600 and @601 is not understood. The mapping data is attached.
- (m) We need to know when the position of D1 and D2 are changed. Let's discuss the best approach.
- (n) The P/T drain line on both DHW tanks should be insulated about two feet from the tank to reduce heat loss.

- (o) If analysis of the flow measurements indicates damper leakage, it should be corrected.
- (p) All drawings are to be updated to the as-built configuration and required manuals and data provided per your contract.

Work on most of these items has been initiated. Mechanical drawings were revised in September to reflect the "as-built" situation at the Akron house.

#### 4.6 Installation Coordination - Proposed Virginia House (OTS-29)

During August, Solaron completed the design and drafting of the preliminary mechanical room heating and cooling piping and rock box sizing. Preliminary duct layout was designed. In addition, Solaron coordinated with T.V.A. on the architectural and structural integration of the system into the building. Further coordination was made with T.V.A. on the solar electrical power load requirements.

In September, coordination continued toward a finalized version of the system design, ductwork layout and piping layout. Preliminary layout of IBM monitoring equipment was coordinated.